



Project Summary Report O-4173-S

Project O-4173: Feasibility of Retrofitting Drainage Facilities
to Improve Water Quality

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Retrofitting Existing Drainage Systems for Water Quality

The U.S. Environmental Protection Agency's (EPA) National Pollutant Discharge Elimination System (NPDES) Phase I rules require stormwater discharge permits for major urban centers. The EPA established Phase II rules that expand the impact of the original Phase I rules for meeting the Clean Water Act, Section 401 provisions.

In order to comply with Phase II rules, all Texas Department of Transportation (TxDOT) districts with urbanized areas of over 50,000 in population will be required to obtain stormwater discharge permits. In addition, new regulations for reducing stormwater pollutant loads may require retrofitting existing drainage structures. Essentially, all districts will likely be required to retrofit and maintain some of the existing drainage infrastructure in order to comply with these provisions.

This project's purpose was to:

- investigate the water quality performance of best management practices (BMPs) suitable for retrofitting,

- evaluate proprietary technologies being marketed for stormwater quality improvement,
- evaluate and make recommendations for selection of stormwater quality BMPs, and
- propose a system for prioritizing the allocation of resources for the installation of retrofit water quality structures.

What We Did...

Research activities included a review of current literature and an assessment of current practice to document the performance of stormwater retrofit technologies. Additional research activities focused on identification of the technologies available for retrofitting existing drainage systems at all scales, as well as exploration of the systems and methods for prioritizing the allocation of resources to retrofit projects. The literature review referenced over 80 publications specifically related to stormwater

quality BMPs, their application, and their performance.

In addition to the survey of existing practice, researchers cataloged and contacted manufacturers of stormwater quality devices in an effort to obtain cost and performance information for use in selecting and designing retrofits.

What We Found...

The Magnitude of the Problem and the Need for Planning

The requirement to retrofit the drainage infrastructure of the state's highway system to improve water quality will continue to escalate over the next decade. The capital requirement to install new structures in urban areas will represent a significant allocation of resources. More importantly, it will require a significant new commitment of resources for maintenance. Depending on the kind of structure and the area served, maintenance costs — including the replacement of filter media as well as cleaning and servicing after every storm

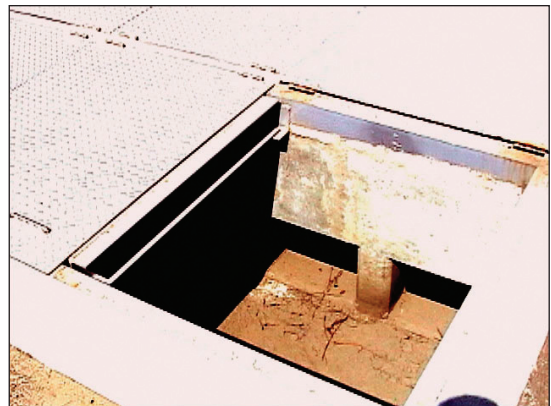


Figure 1. Delaware Sand Filter, California.



event — will run from \$2,300 per year for an extended detention basin to around \$23,000 per year for a large sand filter structure.

By themselves these are not necessarily large numbers, but the applied impact in a district like Fort Worth, which has identified some 460 outfalls in its joint permits with the Cities of Fort Worth and Arlington, can be extraordinary. If only one third of the Fort Worth outfalls (152) required the installation of permanent treatment structures and a mean annual maintenance of \$12,000 per structure is assumed, this scenario would represent a budgetary commitment of \$1,836,000 annually for maintenance alone. This expenditure could become a significant burden on already limited resources. For this reason, TTI researchers recommend TxDOT adopt a planning strategy that will take the need for water quality structures into account early in the planning process so that sufficient right of way (ROW) can be acquired to minimize the need for more expensive, small-footprint-type structures.

Review of Literature and Current Practice

The literature covers a wide range of BMPs that are available for retrofit. Practically any of the basic BMPs can be used for off-line retrofit. The biggest problem with the use of these BMPs is that in the urban areas of the state space to develop appropriate BMPs is extremely expensive or, in some cases, not available. In these situations small-footprint, underground structures must be used if treatment must be provided.

Available Technologies to Improve Stormwater Quality

There are numerous types of BMPs that have been developed to improve stormwater quality, both generic and proprietary. This project looked at a full range of options. Based on the information that was available in the literature with respect to water quality performance, space required, and overall cost for installation and maintenance, it appears that the variety and performance of non-proprietary technologies are sufficient that proprietary technologies would probably have application only in very unusual situations. Figures 1 and 2 show a Delaware sand filter and a detention basin, two non-proprietary BMPs currently used in California.

The guidance section of Report 0-4173-2 provides information on how to select the most appropriate type of BMP for various conditions. One of the current disadvantages of using all non-proprietary BMPs is that each one has to be designed for site-specific conditions. This is generally only a handicap when



Figure 2. Detention Basin, California.

space and time are limited. TxDOT could address this by developing standard details for non-proprietary, modular stormwater BMPs. This is essentially the selling point of most commercially marketed devices.

TxDOT's Resources with Potential for Retrofit

In intensively developed urban centers, water quality structures installed underground substantially increase the cost of retrofitting for water quality. In all likelihood, certain retrofit projects will require some use of underground structures. However, as demonstrated in the very limited review of the Houston IH 610 and IH 10 corridors, many urban freeway systems have interchanges that represent significant land resources. Figure 3 shows an area located on IH 610 at US 59S where stormwater overflow collects. Watermarks on the columns provide evidence that this area retains runoff and has retrofit potential for water quality. Researchers recommend TxDOT inventory, preserve, and prioritize resources like these for development.

Retrofitting in Flat Terrain

Very flat terrain complicates retrofitting projects. In addition, flat terrain combined with a high water table seriously limits retrofit options. In these situations, the only economical way to treat stormwater is with surface-based structures because of the lack of head to move the water through the structure. Most proprietary technologies, particularly those that operate on centrifugal principles, will not operate effectively. The only retrofit option then would be to go underground, which would require the use of pumps to move the water

out of the treatment chamber and to the release point. For this reason, cities and districts in the coastal regions of the state should begin planning immediately to conserve and/or acquire ROW for use as surface treatment of stormwater.

Lack of Documented Operational and Maintenance Costs

The literature contains some limited cost information. However, it is very general and does not include sufficient information about the proprietary technologies. Researchers requested cost information about installation and maintenance from all the manufacturers and marketers of proprietary technologies listed in the final report. Not a single manufacturer replied. Toward the end of the study, researchers attempted to contact locations with installations, but resources were simply not available to visit and generate the data needed to make any meaningful conclusions.

Lack of Documented Hydraulic Performance Data

The most troubling finding to this point is the lack of any significant data on the hydraulic performance or impact of the in-line stormwater BMPs. This is a critical consideration when retrofitting an existing drainage system. Even when a BMP is installed off-line, where the stormwater is diverted into the BMP out of the direct line of flow, there is some loss of energy that must be taken into account. The lack of good hydraulic performance data creates a potential for unwanted outcomes such as traffic hazards and property damage caused by flooding.





Figure 3. IH 610 at US 595, Houston, Texas.

Water Quality Performance of Retrofit BMPs

Water quality performance is reasonably documented for almost all of the generic and non-proprietary BMPs. In this regard, it is important to understand that performance is measured as the annual mean mass of a pollutant removed. The documentation of all the monitoring studies in the literature demonstrates that single event performance of BMPs varies significantly. This variation cannot be fully explained, but it appears to be related to variables such as total pollutant load of the event, period between precipitation events, average daily traffic (ADT) prior to and during an event, climatic variations, and the resident wildlife population.

There are national efforts underway to better understand the performance of the full range of BMPs used for stormwater quality improvement. At this point, though, sufficient data have been collected that can provide enough separation between types to make informed decisions about the most appropriate BMP for a particular situation. Methods for making a selection are provided in the guidance sections of Report 0-4173-2.

The Researchers Recommend...

Implementation

The detailed research report contains two guidance documents. The first guidance document provides a method for selecting an appropriate structural retrofit for improving stormwater quality. The second describes a system for prioritizing the allocation of resources for retrofitting.

Researchers recommend TxDOT include procedures in the appropriate online TxDOT design manual. This will complement the recommended procedures for estimating pollutant loadings and structure sizing provided in Report 1837-1. It will also provide the background information needed for training TxDOT staff.

Performance of Stormwater Quality BMPs

There has been a great deal of research and monitoring directed to the determination of the water quality performance of numerous types of BMPs. The major gap in the information has been in the documentation of the performance of proprietary BMPs. However, this past year the Washington Department of Transportation, with the Environmental Technology Evaluation Center of Washington D.C., initiated a study to perform side-by-side testing of these technologies. This study will fill the gap in water quality performance information for this group of BMPs. TxDOT should continue to follow these efforts and update the manual as more precise information becomes available.

Because the issue of BMP water quality performance has significance nationwide, researchers recommend that TxDOT consider the development of a pooled-fund study aimed at developing a better understanding of performance properties of the various BMPs. This study could build on the experiences of Texas, California, and Washington and provide much needed baseline information to get a wider range of BMPs approved by the Texas Commission on Environmental Quality (TCEQ).

Develop Modular Details for Generic Stormwater Quality BMPs

Researchers recommend that TxDOT consider developing a series of standardized, modular details for small-footprint generic BMPs that can be used when surface basins and ponds will not fit the site.

Study of Hydraulic Properties of Key Technologies

The most significant weakness in all of the literature on BMP performance, particularly with respect to retrofitting, is the lack of research and information on hydraulic performance. TxDOT should rank hydraulic performance as a critical consideration in retrofitting an existing drainage system.

There needs to be an effort to evaluate the hydraulic performance of selected BMP technologies so that the stormwater quality treatment can be added to existing systems without reducing the performance of the existing drainage system.

Development of Field-Based Cost Data

Cost information on construction and maintenance is very limited. Manufacturers of proprietary BMPs appear very reluctant to address the issue of cost. While there have been some efforts to develop costs related to construction, maintenance costs are virtually undocumented. This is a matter of considerable concern. For this reason, researchers recommend that TxDOT consider an effort to document the long-term costs associated with the various BMPs.

Prioritization Process

The prioritization process outlined in this report has not been tried. While it follows the basic process developed by the Washington State Department of Transportation clearly, it needs to be calibrated to meet regional differences in Texas, probably on a district-by-district basis. The original project proposal included an option for a second year in which this type of calibration could be done. TCEQ will likely begin developing total maximum daily loads (TMDLs) for pollutant levels that will impact TxDOT. In addition, there will be a need to allocate resources for stormwater quality retrofit activities. Therefore, the researchers recommend that TxDOT consider a pilot project to calibrate this system to meet their needs.



For More Details . . .

The research is documented in Report 0-4173-2, *Retrofitting TxDOT Drainage Structures to Improve Stormwater Quality*.

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TxDOT Implementation Status *March 2004*

The research investigated generic stormwater quality technologies to help TxDOT in meeting Clean Water Act requirements. The research resulted in two guidance documents. The first provides a method for selecting appropriate structural retrofits for improving stormwater quality. The second describes a system for prioritizing the allocation of resources for retrofitting. The guidance documents have been implemented to improve BMP selection.

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